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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
BÖRSCHER, V. et al.

Serial No: 10/755,532

Filing Date: January 12, 2004

Title: POWDER COATED ROTOR

Commissioner for Patents
P.O. Box 1450
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CERTIFICATE OF MAILING

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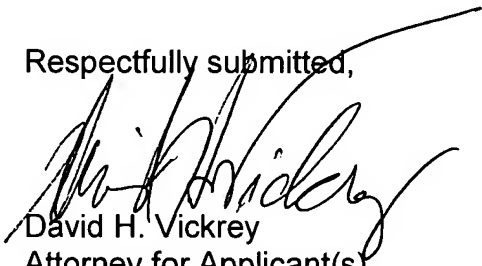
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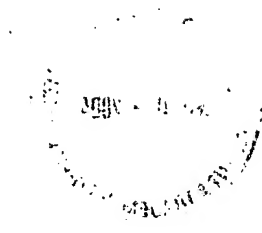
SUBMISSION OF CERTIFIED PRIORITY DOCUMENT

Enclosed herewith is a certified copy of European Patent Application No. 01200960.1, to support the claim of foreign priority benefits under 35 U.S.C. §119 in connection with the above-identified application.

Respectfully submitted,


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Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

01200960.1

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

DEN HAAG, DEN
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se référer à la description.)

Powder coated rotor

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s)
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Powder coated rotor

The present invention relates to a powder coated rotor that is used in an electrical motor or generator. Such rotor, which can also be referred to as
5 armature, is the part in the motor that acts as the support for the coil windings that are present in an electrical motor or generator.

When an electrical motor or generator is in operation, in addition to a movement of the motor, it will also generate heat. This heat causes all parts in the motor to expand, in particular the coils that are wound around the rotor. When the motor
10 is switched off, it cools down again and the heated parts shrink. During the lifetime of the motor, this heat-cycle is repeated very often.

To prevent electrical contact between the rotor and the coil, the rotor and the coil are coated with an insulating material, normally a coating.

In the heat cycle, the coils that are close to the rotor move somewhat with
15 respect to the surface of the rotor and in view of the tension that is on the coil to keep the coil attached to the rotor, this moving coil causes abrasion of the coated rotor. When the coating on the rotor is abraded away to a large extend, short-circuiting will occur and the rotor can no longer be used.

It was found that in addition to a good adhesion to the surface of the rotor, the
20 coating also needs to have a high cut-through resistance to be able to provide a rotor for an electrical motor or generator with a long lifetime. In addition it was found that the coating can also be used to coat the stator or field coil of an electrical motor or generator or a toroid or toroidal tape core.

25 When coating metal articles with a somewhat irregular shape, like, for example, rotors for electrical motors or generators it is very advantageous to use a powder coating. In addition to the well-known advantages of powder coatings as pollution-free, energy-saving, resource-saving, and labour-saving products, for irregular shaped metal objects the use of powder coatings also enables the
30 application of a coating layer with a uniform thickness and a good edge coverage.

The use of powder coatings for the coating of rotors is known in the art. In view of their good cut-through resistance, nowadays anhydride-containing powder coating compositions are used, e.g., Resicoat RT ex Akzo Nobel. However, the use of anhydride-containing materials is not preferred in view of the health and safety risks that are associated with the use of these materials. Further it was found that the long term storage stability of these compositions can be improved. Long term stability tests are based on heat resistance tests, melting points, DSC scans and roughness profiles of the applied and cured compositions, since the properties of the applied and cured coating will deteriorate when the stored composition is no longer stable.

In US 5,449,737 an urethane modified epoxy resin coating composition is disclosed. Nothing is said about the storage stability of this coating composition nor about the cut-through resistance of the coating. The coating compositions are not used to coat the rotor of an electrical motor or generator.

In US 4,923,910 an anhydride-free epoxy powder coating is disclosed that is used to fix the rotor coil of motors and generator to the rotor core. In this publication, the powder coating is used as a kind of adhesive for the coil. Nothing is said about the storage stability of this coating composition nor about the cut-through resistance of the coating. The coating compositions are not used to coat the rotor surface. Articles coated with the powder coating compositions disclosed in this publication show an inferior cut-through resistance in comparison to the articles according to the present invention.

A powder coating composition was found with a good storage stability, that is anhydride-free, and that is also very suitable for use as a coating for rotors for electrical motors or generators in view of its high cut-through resistance. This composition is a thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin, and a curing agent for the resin.

In EP 0 113 575 a polyoxazolidone powder coating composition is disclosed. It is said that the composition can be used for coating metal substrates. Nothing is said about the storage stability of this coating composition nor about the cut-trough resistance of the coating. No reference is made to the use of this
5 composition for the coating of the rotor of an electrical motor or generator.

The present invention relates to a rotor for use in an electrical motor or generator coated with a powder coating wherein the powder coating is obtained by curing a thermosetting powder coating composition comprising an epoxy-
10 terminated polyoxazolidone resin, and a curing agent for the resin.

The invention further relates to the use of a thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin and a curing agent for the resin as a coating for a rotor in an electrical motor or
15 generator.

The epoxy-terminated polyoxazolidone resin that can be used according to the present invention can be obtained by reacting a stoichiometric excess of a diepoxide with a diisocyanate. Preferably the reaction conditions are chosen
20 such that a low molecular weight, epoxy terminated polyoxazolidone resin is obtained.

Epoxy-resins that can be used in the preparation of an epoxy-terminated polyoxazolidone include diglycidyl ethers of aromatic, aliphatic, cycloaliphatic or
25 heterocyclic compounds, for example, diglycidyl ethers of bisphenol A, diglycidyl ethers of hydrogenated bisphenol A, diglycidyl ethers of bisphenol F, diglycidyl ethers of novolacs, or diglycidyl ethers of polyglycols. Examples of commercially available suitable epoxy resins are EPON 828, EPON 825, DER 330, DER 331, DER 332, DER 337, and DEN 431.

Isocyanates that can be used in the preparation of an epoxy-terminated polyoxazolidone include isocyanates that can be represented by the formula $R-(NCO)_k$ wherein k is 2 and R represents a divalent aliphatic hydrocarbon group having 2 to 18 carbon atoms, a divalent cycloaliphatic hydrocarbon group having 5 to 15 carbon atoms, a divalent araliphatic hydrocarbon group having 7 to 15 carbon atoms or a divalent aromatic hydrocarbon group having 6 to 15 carbon atoms. Examples of the organic diisocyanates which are particularly suitable include ethylene diisocyanate, 1,3-propylene diisocyanate, 1,4-tetramethylene diisocyanate, 1,6-hexamethylene diisocyanate (HMDI), 2,2,4-trimethyl-1,6-hexamethylene diisocyanate, 2-methyl-1,5-diisocyanate pentane, 2-ethyl-1,4-diisocyanate butane, 1,12-dodecamethylene diisocyanate, cyclohexane-1,3- and -1,4-diisocyanate, 1-isocyanato-2-isocyanatomethyl cyclopentane, isophorone diisocyanate (IPDI), bis-(4-isocyanatocyclohexyl)-methane, 2,4'-dicyclohexylmethane diisocyanate, 1,3- and 1,4-bis(isocyanatomethyl)-cyclohexane, bis-(4-isocyanato-3-methyl-cyclohexyl)-methane, 1-methyl-2,4-diisocyanato cyclohexane, 1-isocyanato-1-methyl-4(3)-isocyanatomethyl cyclohexane, xylene diisocyanate, 1-methyl-2,4-diisocyanato benzene, $\alpha,\alpha,\alpha',\alpha'$ -tetramethyl-1,3- and -1,4-xylylene diisocyanate, 2,4- and 2,6-hexahydrotoluylene diisocyanate (TDI), 1,3- and 1,4-phenylene diisocyanate, 2,4- and 2,6-toluylene diisocyanate, 2,4- and 4,4'-diphenylmethane diisocyanate (MDI), 1,5-diisocyanato naphthalene, norbornane diisocyanate, and mixtures thereof.

Preferably MDI, TDI, or HMDI are used in the preparation of the epoxy-terminated polyoxazolidone.

Preference is given to polyoxazolidones having an epoxy equivalent weight in the ratio from 250 to 4000 that can be prepared by reacting diepoxide and diisocyanate reactants in a ratio of epoxide equivalents to isocyanate equivalents from 5:1 to 1,1:1, preferably in the range from 3:1 to 1,2:1.

A condensation catalyst can be used in the reaction to form the polyoxazolidones. Such catalysts include those conventionally used for this

type of reactions between epoxides and isocyanates, such as quaternary ammonium halides, tertiary amines, lithium halides, lithium halide-phosphonium oxide complexes, n-butoxy lithium, dialkyl zinc, organozinc chelate compounds, trialkyl aluminium and dibutyltin dilaurate.

- 5 The reaction can be carried out in a solvent, for example, in lower alkanols or dimethylformamide at a temperature in the range from 75 to 200°C.

The powder coating composition that is used according to the present invention further comprises a curing agent for the epoxy-terminated polyoxazolidone
10 resin. Such curing agent are well known in the art and include polyamines, polyamides, polyaminoamides, polyphenols, polymeric thiols, polycarboxylic acids, polyols, imidazoles, tertiary amines and quaternary ammonium halides. These latter three curing agents can also act as an accelerator for the curing reactions. Examples of imidazoles that can be used as curing agent and curing
15 accelerator include 2-styrylimidazole, 1-benzyl-2-methylimidazole, 2-methylimidazole and 2-butylimidazole.

The powder coating composition can further comprise fillers and/or additives to improve the properties of the coating, such as stabilisers, antioxidants, levelling agents, antisetling agents, matting agents, rheology modifiers, flexibility
20 agents, surface-active agents, UV light absorbers, light stabilizers, amine synergists, waxes, or adhesion promoters. Further the coating composition can comprise one or more pigments.

In addition to the resin components mentioned above, the coating composition
25 can also comprise additional resins, such as 0 - 30, preferable 5 - 20, percent by weight of an epoxy resins or a mixture of epoxy resins, such as DER 663, DER 664, DR 667, or 0 - 30, preferably 5 - 20 percent by weight of an epoxy novolac or a mixture of epoxy novolacs, such as DER 642, DER 672, Araldit ECN1299 or Araldit ECN9699.

In a preferred embodiment the powder coating composition used according to the present invention comprises:

- 30 - 90, preferably 40 - 50 % by weight of the powder coating composition of a polyoxazolidone resin or a mixture of polyoxazolidone resins;
- 5 - 0,1 - 40, preferable 5 - 15 % by weight of the powder coating composition of a curing agent or a mixture of curing agents;
- 0,1 - 50 % by weight of the powder coating composition of an additive or a mixture of additives and/or a filler or a mixture of fillers.

10 The powder coating composition can be made by any process wherein all ingredients of the composition are uniformly mixed. For example, the composition can be prepared by intimately mixing the ingredients in an extruder at a temperature above the softening point of the film forming polymer(s), but below the temperature at which significant pre-reaction would occur. The
15 extrudate is usually rolled into a flat sheet, allowed to cool, and broken down into small particles, for example by grinding. Normally, the powder coating particles should have an size below 300 μm , preferably an average size in the range from 100 to 200 μm .

20 The powder coating can be applied to the rotor by any known powder coating process. Fluidized bed sintering, electrostatic powder coating or an electrostatic fluidized bed process are preferred. For the coating of a rotor with a powder coating composition comprising an epoxy-terminated polyoxazolidone resin the electrostatic fluidized bed process is preferred. In such process the rotor is
25 normally heated to a temperature in the range from 180 - 260°C. Normally the coating is applied at a film thickness in the range from 250 to 500 μm .

The rotor coated with a thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin, and a curing agent for the resin
30 can be used in all type of electrical motors or generators. For example, the rotor can be used in small-size electrical motors that are used in household and

automotive appliances, but the coated rotor can also be used in larger-size electrical motors or generators or drilling machines. The thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin can also be used for coating field coils, stators, toroids, or toroidal tape cores.

5

The invention will be elucidated with reference to the following examples. These are intended to illustrate the invention but are not to be construed as limiting in any manner the scope thereof.

10 **Examples****Example 1**

A powder coating composition was prepared having a density of 1,65 - 1,75 g/cm³ and less than 0,5 wt.% of particles with a size above 200 µm was prepared by mixing the following compounds:

15 35 - 45 pbw of a polyoxazolidone resin (reaction product of Bisphenol A diglycidylether and MDI),

5 - 15 pbw of a phenolic hardener,

<1 pbw of an imidazole, and

45 - 55 pbw of additives and fillers.

20 This powder coating composition was applied to a in a fluidized bed process and cured at a temperature in the range of 200 - 240°C.

The obtained coated rotor was coated with a smooth film with a thickness in the range from 250 - 500 µm. The film had a gloss (measured according to DIN 67530) of 80 - 100 units, an impact resistance (measured according to DIN

25 30671) of 10 Joule, a hardness (measured according to DIN 53153) > 100, and an edge coverage > 40%, a breakdown voltage > 30 kV/mm, and a high cut trough resistance at a temperature above 300°C.

Example 2.

30 The storage stability of a thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin, and a curing agent for the resin as

prepared in example 1 was compared to the stability of a commercially available anhydride containing thermosetting powder coating composition.

Freshly prepared samples of both coatings were applied to a rotor and cured into a smooth coating film. Part of these samples were stored at 23°C and after 5 6 months storage applied to a rotor. The 50% cut through temperature, the melting point (T_m), the glass transition temperature (DSC T_{g1}) and the roughness of the cured coating film of the samples was measured. The results are presented in the table below.

	Example 1		Anhydride powder coating	
	Fresh powder	6 months @ 23°C	Fresh powder	6 months @ 23°C
50% cut through temperature	300°C	300°C	310°C	260°C
T_m	99°C	99°C	84°C	98°C
DSC T_{g1}	69°C	69°C	63°C	73°C
Roughness	5 μm	5 μm	2 μm	> 30 μm

10

The results above clearly show that the properties of the anhydride containing powder coating composition deteriorate when the composition is stored for some time. The composition comprising an epoxy-terminated polyoxazolidone resin shows very good properties even after storage for longer time.

15

Claims

1. Rotor, stator, or field coil for use in an electrical motor or generator, a toroid or a toroidal tape core coated with a powder coating, characterized in that the powder coating is obtained by curing a thermosetting powder coating composition comprising an epoxy-terminated polyoxazolidone resin, and a curing agent for the resin.
5
2. Rotor, stator, field coil, toroid or toroidal tape core according to claim 1, characterized in that the powder coating composition comprises
10 30 - 90 % by weight of the powder coating composition of an epoxy-terminated polyoxazolidone resin, and
0,1 - 40 % by weight of the powder coating composition of a curing agent for the resin.
- 15 3. Rotor, stator, field coil, toroid or toroidal tape core according to claim 1 or 2, characterized in that the powder coating composition comprises an epoxy-terminated polyoxazolidone resin obtained by reacting an diepoxide with
1,6-hexamethylene diisocyanate, 2,6-hexahydrotoluylene diisocyanate or
4,4'-diphenylmethane diisocyanate.
20
4. Rotor, stator, field coil, toroid or toroidal tape core according to any of the preceding claims, characterized in that the powder coating composition comprises an epoxy-terminated polyoxazolidone resin obtained by reacting a diisocyanate with a diglycidyl ether of bisphenol A or a diglycidyl ether of novolac.
25
5. Rotor, stator, field coil, toroid or toroidal tape core according to any of the preceding claims, characterized in that the powder coating composition comprises an epoxy-terminated polyoxazolidone resin obtained by reacting
30 a diisocyanate selected from the group consisting of 1,6-hexamethylene diisocyanate, 2,6-hexahydrotoluylene diisocyanate, and 4,4'-

diphenylmethane diisocyanate, with a diepoxide selected from the group consisting of a diglycidyl ether of bisphenol A and a diglycidyl ether of novolac.

- 5 6. Use of a powder coating composition comprising an epoxy-terminated polyoxazolidone resin, and a curing agent for the resin for the coating of a rotor, stator, or field coil in an electrical motor or generator, a toroid or a toroidal tape core.
- 10 7. Use according to claim 6, characterized in that the powder coating composition comprises
- 30 – 90 % by weight of the powder coating composition of an epoxy-terminated polyoxazolidone resin, and
- 0,1 - 40 % by weight of the powder coating composition of a curing agent
- 15 for the resin.

Abstract

Rotor, stator, or field coil in an electrical motor or generator, a toroid or a toroidal tape core coated with a powder coating, obtained by curing a thermosetting powder coating composition comprising an epoxy-terminated
5 polyoxazolidone resin, and a curing agent for the resin. The polyoxazolidone resin can be the reaction product of a diisocyanate selected from the group consisting of 1,6-hexamethylene diisocyanate, 2,6-hexahydrotoluylene diisocyanate, and 4,4'-diphenylmethane diisocyanate, with a diepoxide selected
10 ether of novolac.

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